RC-3086
(Tentative)
March 16, 1977

GENERAL TEST OR TROUBLESHOOTING GUIDE FOR FBK-HIGH SPEED TRIP UNITS (125Vdc Control Power)

This guide describes general procedures which are recommended for isolation of functions or problems, if any, of standard High-Speed Trip units (HST's). It is not intended to cover detailed bench test, calibration or component test procedures but includes initial tests or symptom checks preliminary to extended tests or investigations.

Refer to Instruction Books IB-16.4.1.7-1 and -2 for basic information on units. (Also called 76 HS.)

Introduction

HST units consist of several circuits or functional blocks typically shown in Figure 1. All circuits should be in proper operating or calibrating condition to obtain a functional system. External HST settings should correspond to actual loading of the breaker and be selected to respond to faults or overloads in the power system.

Basic functions of the blocks are as follows:

(a) Power Path

PC 100 receives 125V control power for a HST unit from a station battery, steps it down for inverter usage and regulates or holds it constant. Whereas the reference zener diode and small components are on a removable card, the power regulating transistor is mounted on a stationary heat sink. PC 100 also produces signal power for the inverter and contains transient protection to suppress voltage spikes or surges which may exist on the station battery wiring.

The circuitry of PC 100 and PC 200 is floating, i.e., not grounded and hence, follows the battery bus potentials with respect to ground.

PC 200 inverter circuit converts regulated DC voltage to a square wave AC output of medium frequency.

A transformer mounted on a stationary HV panel C-600 steps up the voltage to a high value and supplies a HV rectifier. HV rectifier holds a HV capacitor charged with energy for tripping. A trigger type spark gap is used to discharge the stored energy into an impulse trip coil. HV circuit is connected to the breaker frame, i.e., is grounded if the frame is grounded.

PC 500 regulated LV DC power supplies are fed by another output of the transformer and provide control power for operation of all signal, test and triggering circuits. A control relay with permissive contacts ("close function") is mounted on PC 500 but is operated by the circuitry of PC 400.

(b) Signal Path

PC 300 amplifies the sensor signal in one direction and compares it with a front set reference for nearly instantaneous tripping. The card provides also an input signal for PC 800 (if used) and excitation or DC bias for the sensor. Test PB overrides the amplifier to produce a tripping signal.

If used, PC 300X provides functions similar to PC 300 in another tripping direction except that rate-of-rise PC 800 is deleted in dual-directional trip assemblies.

PC 400 produces triggering signals for the HV spark gap, hence for HST tripping. PC 400 circuit also supervises the HV capacitor voltage and through a relay on PC 500, does not allow circuit breaker closing unless the voltage is above the minimum level of 1800V. A wire jumper on PC 400 determines if HV capacitor will be automatically discharged into the trip coil, hence causing breaker tripping, when the battery voltage or the LV power supply is lost for any reason.

Jumper A-B (std.): Trip on control power loss.

Jumper A-C: No trip on control power loss.

PC 800, if used, detects rate-of-rise of the breaker current and is internally calibrated for 1X sensor rating A/sec. slope. External settings allow adjustments of the R/R output delay to ride through load or train start ups. R/R function has its own Test PB.

A fuse is used in the control power input lead (battery supply) to disconnect standard HST units in cases of repetitive breaker reclosing on a faulted bus, repetitive or false sensor signals, misadjusted or faulty breaker trip mechanisms, wiring shorts and internal HST misadjustments or malfunctions. The purpose of the fuse is to prevent excessive number of HV capacitor discharge and charge cycles, limit internal temperature rise and localize damage.

Note, that removal of any card in the signal or power path will disable HST either partially or completely (see Table I). Hence, PC 100, 200, 300, 400 and 500 cards should always be plugged in unless special tests are being conducted.

Precautions

High-Speed Trip units contain solid-state (semi-conductor) components, hence normal precautions applicable to semi-conductor equipments should be taken.

For example:

1. Incorrect wiring may result in damage.

2. The control power source must be a stable supply, such as a battery equipped with a charger. Reasonable care must be exercised with other sources and the loads on the source so that the transient variations do not cause too much stress on the semiconductor components in the trip device. If the control line is unusually "spikey", varistors, or some other form of surge suppression must be placed across the line serving this equipment.

3. Apply only the rated control voltage within specified limits. See IB-16.4.1.7-1, Table 2. The limit applies also to battery charger settings under charging, floating, or equalizing conditions.

4. Do not apply high voltage tests to HST units. See IB-16.4.1.7-1, Table 1 and text.

5. Weight of a HST box is approximately 35 lbs. Handle with care and avoid drops, excessive shocks or mechanical damage to components or enclosures.

6. Circuit boards should insert smoothly and be seated properly in assigned positions and connectors.

7. If HST is fused on the control power side, use replacement fuses only of a slow-acting, time-delay type as follows:

   125V dc control - 3/4A, 250V, size 3AG-SB slow acting,
   Little Fuse - Slo-Blo #313.750S
   or Bussman - type MDL

   250V dc control - 1/2A, 250V, size 3AG, slow acting,
   Little Fuse - Slo-Blo #313.500S
   or Bussman - type MDL

   } Do Not substitute

8. It is recommended that the frame control power switch be opened prior to replacement of a HST fuse. Make sure that the HST fuse holder is seated properly and there are no intermittent connections between the battery and HST unit.

9. Normal control power requirements per HST unit = approximately 0.3A steady state (FBK closed or open).

   If total station battery power is lost for any reason and the size of the battery, charger or wiring is marginal, do not restore control power to a large number of breakers at the same time to avoid excessive control voltage dips. Open control power switches or pull control fuses in each frame and reapply battery power one at a time.

   Inrush current to each HST unit (capacitor charging) is approximately 1.7-1.9A peak, decaying to 0.3A in several seconds (@ 125V).

10. Do not operate HST built-in test push buttons in rapid succession. Allow at least 30 seconds between tests to assure proper cooling after recharge.

11. Do not interchange HST units or cables which have different catalog or manufacturing numbers.

12. WARNING: High Speed Trip units contain 2.5 kV high voltage circuits and hence, must be handled with proper care.

    (a) Do not disconnect cables from HST to FBK trip coils or from HST to slave units unless control power is removed.

    (b) After removal of control power, allow at least 5 minutes before disconnecting the above cables.

    (c) If HST is opened for inspection, short circuit the HV capacitor to the steel box using a well insulated jumper or short-circuiting plugs on HV connectors.

    (d) While bench testing, do not connect control power to a HST unit unless the HV capacitor short-circuiting jumper is removed: Stay away from HV circuits or connectors during tests. Any meter or oscilloscope for high voltage measurements should be insulated and not handled during tests.

    (e) Make sure the short-circuiting jumpers are removed before HST is reconnected to the circuit breaker.

Placing the Equipment into Service

Before energizing or placing a HST unit into service, it should be examined for shipping damage. Verify that HST fuse is intact and external cables or connectors are properly connected. In case of damage, open HST enclosure and inspect for damaged components, assemblies or wiring.

Since power levels at HST battery or output side are much higher than millivolt signal power at the sensor side, a HST unit is considered to be in operation as soon as battery control power is applied and irrespective of circuit breaker position or main system power availability. Therefore, the unit should be checked and tested at the time of first application of battery power to verify and record its operational status.

If other devices in a switchboard are being initially tested for operation or calibration and the HST unit is not in use, it is recommended that HST fuse be removed so as to prevent HST accidental damage in case of other external problems or errors. In this case and if closing and tripping of the circuit breaker by means of other switches or relays are desired, a temporary jumper should be installed on the breaker between appropriate control terminals to by-pass HST interlock contact in the closing circuit.

It is also recommended that a FBK-HST Test Accessory type TA-3M be used during initial control power energization of a HST unit for quick checks of the circuit operation. Refer to Instructions RC-3087 for TA-3M use. (OPTIONAL Accessory)

The push-to-test button on the front panel of a HST unit allows a convenient means for checking all circuits in the high-speed trip control assembly. When the button is depressed, the breaker will trip if the unit is in operable order.

A separate push-to-test button is provided with those devices containing the 76HS-RR Detector. When this button is depressed, the breaker will trip after the time delay selected.

NOTE: Where automatic reclosing circuitry is provided, the above two tests shall only be made when the breaker is in the TEST position or if the reclosing circuit is disconnected during the test.

Breaker Tripping

If undesirable FBK-H breaker tripping occurs, normal trouble-shooting procedures should be followed to isolate the cause and operating conditions and to identify the device or equipment responsible.

For example, the breaker tripping may be caused by:

1. Electro-magnetic trip (OD FBK)
2. High-speed trip (HST) (76 HS)
3. Shunt trip coil and associated devices
4. Undervoltage trip or associated devices (optional)
5. Breaker mechanism (if misadjusted)

No matter what procedures or methods are used, the identification and trouble-shooting will be simplified, if the equipment is observed during abnormal operation and operating conditions and symptoms are noted.

HST Trouble-Shooting

All HST units are factory tested, calibrated and should offer reliable service. Installation and test personnel should be thoroughly familiar with HST operation and instructions, use proper test methods and take necessary precautions especially during initial phases of the installation.

Internal HST testing or trouble-shooting should be conducted only by experienced personnel versed in appropriate procedures and methods, and using proper instruments and test points.

Initial correction of problems, if any required, should be limited to verification of the problem, external setting adjustments, HST unit interchange, fuse replacement or circuit card replacement.

If HST fuse blows, it should be replaced at least once to verify that the suspected malfunction persists.

All standard HST units and cards are calibrated identically, hence could be interchanged with those having the same catalog or manufacturing numbers.

Built-in test push buttons and Test Accessory Type TA-3M are convenient tools for fast checking of the suspected malfunctions.

If PC board interchange is contemplated, consult Table II for evaluation steps to avoid incorrect conclusions. The table is not based on performance and the conditions are assumed merely to explain circuit and function interaction.

HST extension cables could facilitate quick trouble-shooting and card replacement, if required. Extender cards will simplify bench testing.

Isolation of Problems

If faults are absent and identification of a device or tripping reason is desirable, isolation of causes may require temporary removal of one of the protective functions. However, such tests should be conducted under close supervision and with trip stand-by.

The following tests or adjustments can be permitted only by personnel responsible for the system:

1. If tripping occurs during car or train starts, verify by observing bus ammeters and increase HST settings. If at limits, consult factory for special calibration.

2. To temporarily defeat rate-of-rise tripping, remove PC 800.

3. To disable HST, remove its fuse or PC 400 (PC 300X - only one direction), if electro-magnetic trip (OD) remains in service.

4. To temporarily defeat undervoltage tripping, by-pass associated contacts.

5. To temporarily defeat shunt tripping, disconnect the suspected device.

For breaker adjustments and maintenance, refer to IB-16.4.1.7-1.

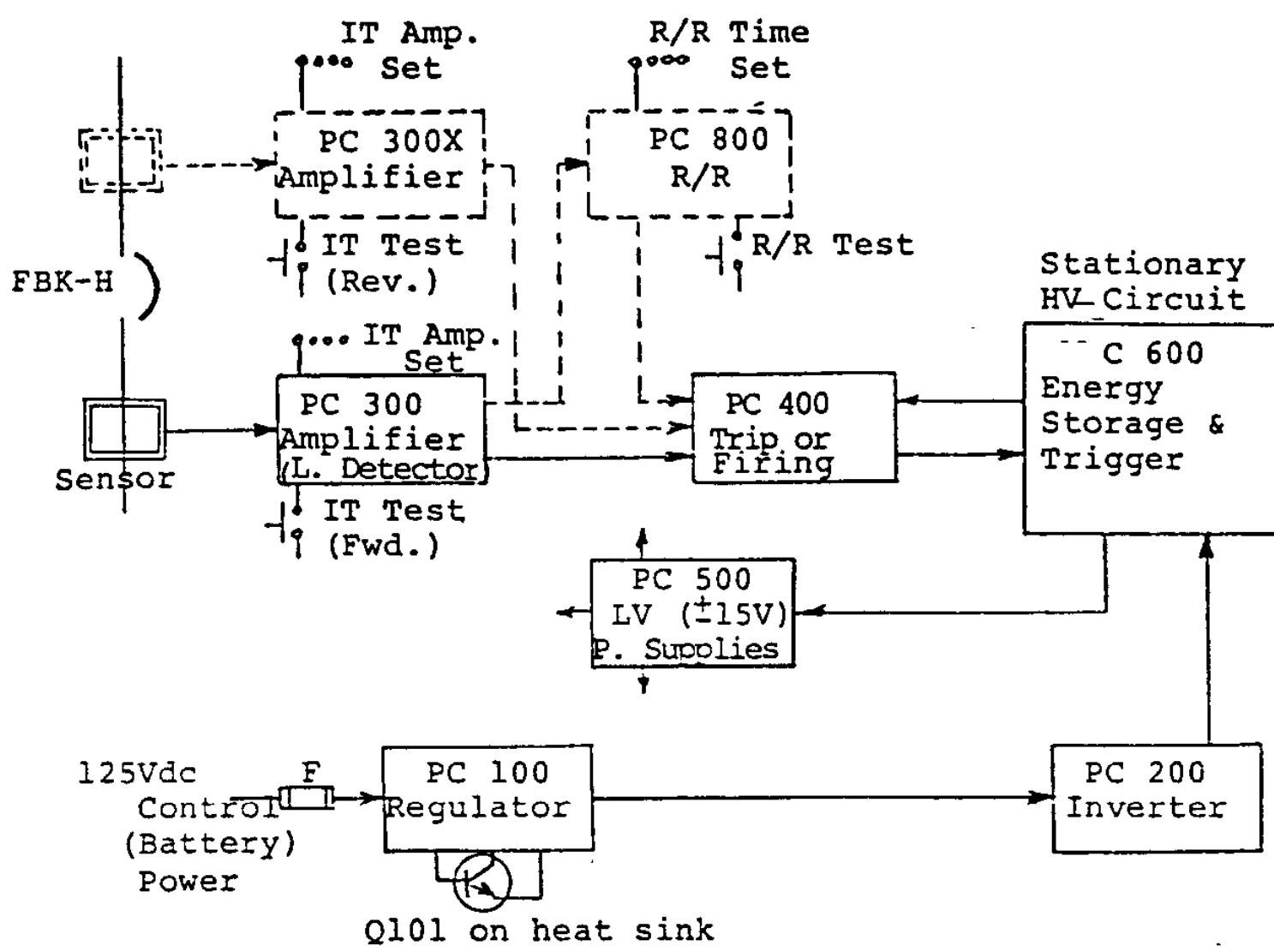

FIG. 1 FBK-HST BLOCK DIAGRAM (76 HS)

TABLE I. EFFECT OF PC CARD REMOVAL

	Operation Retained				HST Function Removed
	IT Test PB	R/R Test PB	HS Trip	Trip Power	
PC 100	No	No	No	No	All
PC 200	No	No	No	No	All
PC 400	No	No	No	Yes	All
PC 500	No	No	No	Yes	All
PC 300	No	Yes	No	Yes	All
PC 800	Yes	No	Inst. Only	Yes	R/R
PC 300X	One of Two	Yes	Unidirect.	Yes	One Tripping Direction

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RC-3086
FBK-HST Troubleshooting Guide
FOR
3/16/77
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TABLE II
PC BOARD INTERCHANGE

CONDITIONS & SYMPTOMS	POSSIBLE CAUSE	CHECK & REMEDY
1.1 IT Test PB inoperative. CP available, HST fuse intact. Control current normal. HV normal, inverter hums.	1.1a Amplifiers faulty or misadjusted. 1.1b No trip signal. 1.1c No LV power supply.	1.1a Replace PC 300 or PC 300X. 1.1b Replace PC 400. 1.1c Replace PC 500.
1.2 R/R Test PB inoperative. HV normal.	1.2 R/R circuit faulty.	1.2 Replace PC 800.
1.3 Test PB's inoperative.	1.3a No trip signal. 1.3b No LV power supply.	1.3a Replace PC 400. 1.3b Replace PC 500.
1.4 FBK-H cannot be closed. HST operation normal.	1.4a Misadjusted relay pick-up. 1.4b Open relay coil.	1.4a Replace PC 400. 1.4b Replace PC 500.
1.5 FBK-H cannot be closed. HV zero. HST fuse intact.	1.5a Defective inverter control. 1.5b Defective inverter.	1.5a Replace PC 100. 1.5b Replace PC 200.
1.6 HST does not trip upon CP or fuse removal (abnormal).	1.6 Trip circuit defective.	1.6 Replace PC 400. A-B jumper should be on PC 400.
1.7 HST trips upon CP or fuse removal (abnormal).	1.7 Trip circuit defective.	1.7 Replace PC 400. A-C jumper should be on PC 400.
1.8 Control current 0.5A or Higher.	1.8 Unbalanced inverter.	1.8 Replace PC 200.

TABLE II
PC BOARD INTERCHANGE - (CONT'D)

CONDITIONS & SYMPTOMS	POSSIBLE CAUSE	CHECK & REMEDY
2.1 HST fuse blows. No inverter hum. HV zero.	2.1a Defective inverter. 2.1b Defective regulator.	2.1a Replace PC 200. 2.1b Remove PC 100 but do not replace until power transistor Q101 (on card rack) is tested. Use an ohmmeter (IX scale) between transistor case (collector) and other two pins. Reverse test leads and repeat. If all readings except one (5 ohm) are high, replace PC 100. If any reading is 2 ohm or less, consult factory.
2.2 Any other abnormal condition.	2.2 Use TA-3M test accessory to obtain more data.	2.2 Consult factory.
3.0 Undesirable or intermittent HST operation.	3.0 Wrong trip settings.	3.0 Observe load ammeters during train start-up and change tap plug settings.